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Smoking Guns

SMOKING FLARES AND UNCOUNTED EMISSIONS FROM REFINERIES AND CHEMICAL PLANTS IN PORT ARTHUR, TEXAS

SMOKING GUNS

"Smoking Guns" reviews evidence indicating that large volumes of air pollution are released because flares, a pollution control device in use at many refineries and chemical plants, are poorly operated and do not burn cleanly. The specific plants addressed in this Report are located in Port Arthur, Texas, and include Atofina Petrochemical Inc., BASF Fina Petrochemicals, Chevron Phillips Chemical Co., Hunstman Corporation, Motiva Enterprises, and the Premcor Refining Group, Inc.

The Environmental Integrity Project (EIP) gratefully acknowledges the assistance of Neil Carman of the Lone Star Chapter of the Sierra Club for his valuable comments and suggestions.

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November 2002

The Environmental Integrity Project (EIP) recently released a report documenting excess emissions from startup, shutdown, maintenance, and malfunction practices at local refineries and chemical plants in Port Arthur, Texas (Accidents Will Happen, October 2002, *available at* www.rffund.org). Analysis of upset reports filed by local refineries and chemical plants revealed that at least *725 tons of sulfur dioxide, 10 tons of hydrogen sulfide (H_2S), 844 tons of smog-forming volatile organic compounds (VOC's), nearly 42 tons of benzene, and over 57 tons of carbon monoxide* were released from such incidents at five Port Arthur companies between January and July of this year alone.[1] Alarmingly, pollution totals for certain pollutants such as VOC's and H_2S may be as much as 30 times greater because flares, the primary method of pollution control used during malfunctions and shutdowns, do not appear to be working as well as company reports claim.[2]

Why Are Pollutants Being Underestimated?

Industrial operations at refineries and chemical plants create numerous waste products including purged and wasted products from refineries, unrecoverable gases emerging with oil from oil wells, vented gases from blast furnaces, unused gases from coke ovens and gaseous waste from chemical industries.[3] These waste gas streams, usually consisting mostly of hydrocarbons, are often sent to a flare for combustion, particularly during upset conditions that require prompt disposal of waste gases. Companies assume the flare combustion process will destroy 98-99% of carcinogens like benzene and other hazardous air pollutants entrapped in the waste gas stream. Recent studies, however, indicate that flares achieve this high level of combustion only under optimal conditions such as low wind speed, and only if they are properly maintained and large enough to handle high waste volumes. Moreover, the U.S. Environmental Protection Agency (EPA) has identified visibly smoking flares as being, "far less efficient than properly maintained flares."[4] Examination of upset reports filed by refineries and plants in Port Arthur reveals that many flares are documented as smoking, sometimes heavily, suggesting that facilities release much higher amounts of pollution than companies are reporting.[5]

This report will address the following, all of which are described in more detail below:

- **Smoking Flares Indicate Poor Combustion and Uncontrolled Emissions-** Open air flames performing at the 98-99% efficiency rate standard should not exhibit any visible emissions or smoke from flares. Where a flare is smoking, less than 98-99% of pollutants sent to the flare are being destroyed. As Table A indicates, while companies report smoking flares sometimes for periods as long as three hours at a time, facilities still employ the 98-99% destruction efficiency rate to determine pollutant discharge from the flare. For example, on May 16, 2002, Huntsman Corporation's Aromatic and Olefin refinery reported a release of 5,875 pounds of ethylene from its flare unit assuming maximum destruction efficiency. The company reported that the same flare emitted "heavy smoke for approximately three hours"-an indication that the flare was not completely combusting pollutants and was performing at less than a 98-99% efficiency rate. Even a conservative adjustment for the destruction efficiency rate results in huge increases in the amount of pollutant reportedly discharged. For instance, adjusting the destruction rate to just 90% would increase the total amount of ethylene released from the Huntsman plant event from 5,875 pounds to 58,750 pounds- a ten-fold increase.

- **Smoking Flares Violate Federal Law-** Federal law prohibits flares to smoke for more than five minutes in any consecutive two hour period. Yet, as Table A indicates, companies often report smoking flares for much longer periods in apparent violation of this requirement.

- **Opacity Events May Be Evidence of Additional Smoking Violations-** In addition to reports of smoke coming off of flares, companies also report exceedances of opacity requirements.[6] Opacity refers to the estimated density of emissions from air emission sources, as measured by the capacity of these emissions to block light. Yet, it is unclear from these reports whether high opacity readings correspond to incidents where flares are smoking, or from smoke coming from other plant units.

- **Meteorological Factors Impact Flare Flame Size and Flare Destruction Efficiency-** The 98-99% destruction efficiency rate assumes that certain meteorological conditions are also being met. Most important of these for flame destruction efficiency is the wind speed surrounding the flare, which influences the flare's flame size. When the flame size is less than optimal, flares do not burn as efficiently and therefore destroy less of the pollutant than would be destroyed using standard a 98-99% destruction efficiency rate. What the flame does not destroy gets released into the air and eventually into the surrounding neighborhoods. Wind speed in the Port Arthur Beaumont area is consistently higher than what is required to assume a 98-99% destruction efficiency rate. (Table A provides wind speed data for each of the dates on which companies reported smoking flares.) The high wind speed in Port Arthur produces smaller flame sizes and therefore less efficient combustion by flares.

- **Flaring May Produce More Harmful By-Products than Originally Suspected-** After proper flare destruction, byproducts from flares should be composed entirely of relatively innocuous components such as carbon dioxide ($CO_{2)}$ and water (H_2O). More recent studies, however, suggest that incomplete combustion from flaring could actually be producing more hazardous air pollutants including volatile organic compounds and hydrocarbons.

TABLE A

Reported Smoking Flare Events at Port Arthur Refineries and Chemical Plants‡

Facility Name	Date	Opacity Reading	Duration	Day or Evening	Wind Speed (meters per second)		Additional Information
					Avg.	High	
HUNTSMAN	4/25/2002	"Heavy smoke"	3 hours	Day	3	7.6	
	5/16/2002	"Heavy smoke"	"for approximately 3 hours"	Day	6	8.9	
	6/3/2002	"Smoke"	"for approximately 10 minutes"	Day	4.5	7.6	
	8/14/2002	"Visible emissions"	"for approximately 3 hours"	Day	3.6	9.4	
	8/17/2002	"Light smoke"	5 minutes	Evening	2.8	7.6	
	8/21/2002	"Light smoke"	60 minutes	Evening	1.16	11.2	
	8/22/2002	"Light smoke"	15 minutes	Day	1.7	9.4	
PREMCOR	*Premcor did not report any smoking flares for January-August 2002.**						
MOTIVA	*Motiva did not report any smoking flares for January-September 2002.*						
BASF	3/5/2002	"Smoking flare"	"for 35 minutes"	Day	3.6	7.6	No pollutants reported despite reported smoking.
	5/8/2002	"Smoking flare"	"for 30 minutes" for "intermittent" periods	Indeterminable	7.2	10.7	
	5/12/2002	"Intermittent smoking flare"	Not reported. Total release lasted 113 hours and 32 minutes.	Indeterminable	6.5	11.1	
ATOFINA	*Atofina did not report any smoking flares for January-September 2002.**						
CHEVRON	4/25/2002	percentage not reported	Not reported. Total release lasted 25 minutes.	Day	3	7.6	No pollutants were reported despite reported smoking.
	6/20/2002	smoke	"for approximately 1 ½ hours"	Day	2.5	7.6	

‡ Information taken from final upset reports from TCEQ (formerly TNRCC)

* *Although these facilities did not report observations of smoking flares, they did report high opacity readings associated with flare emissions points. For example, the Premcor facility reported 100% opacity on February 9, 2002. It is unclear from this report, however, if the opacity reading was of smoke from a flare or from some other type of malfunction.*

Smoking Flares Indicate Poor Combustion and Uncontrolled Emissions

Flares represent the primary method of pollutant disposal in use by refineries and chemical plants in Port Arthur. This vapor-combustion control device is designed to destroy pollutants released through a waste gas stream during both routine processes and emergency or upset conditions at refineries and chemical manufacturing plants. EPA's "AP-42 Emission Factor Series" indicates that "properly operated flares achieve at least 98% combustion efficiency in the flare plume" and TCEQ's Air Permit Technical Guidance for Chemical Sources: Flares and Vapor Oxidizers list destruction efficiency rates for flares to range from 98-99% based on the type of pollutant being discharged.[7] Thus, flares operating at maximum efficiency should be destroying at least 98-99% of pollutants being directed to flares.

Currently, Port Arthur facilities assume maximum destruction efficiency has been achieved when reporting their emissions. These plants simply assume that flares are operating at optimum levels, but do not perform real-time monitoring or flare stack testing to demonstrate this claim of 98-99% destruction. Instead, companies estimate emissions from flares based on the results of flare testing conducted in the early 1980's and performed under optimal conditions.[8] However, the evidence in Port Arthur indicates that flares do not always operate at this high level of performance efficiency.

Smoking flares signal that emissions are being combusted at a less than efficient rate. EPA's Office of Air Quality Planning and Standards authorized a report which analyzed the Petroleum Refinery National Emission Standard for Hazardous Air Pollutants (NESHAP). This report noted that, "The efficiency of a flare in reducing VOC emissions can be variable. For example, smoking flares are far less efficient than properly maintained flares." [9] Thus, where flares are smoking, it is incorrect to utilize the 98-99% efficiency rate in determining total pollutant discharge. Yet, facilities in Port Arthur reporting emissions from flares continue to assume a 98-99% efficiency rate in determining pollutant discharge despite reports that their facility's flares are smoking.

Smoking Flares Violate Federal Law

The Clean Air Act prohibits facilities to operate with smoking flares except for very short periods of time. Both state and federal regulations require that, "Flares shall

be designed for and operated with no visible emissions except for periods not to exceed a total of five minutes during any two consecutive hours."[10] Despite this clear state and federal requirement, many flares are reported to be smoking for longer than five minutes and many other smoking events not reported by facilities are observed by community residents.

Table A summarizes smoking flare events in Port Arthur from January through August of this year that were reported by area refineries and chemical plants. Several of these smoking events lasted for periods as long as three hours. Smoking flares which last for more than five minutes in any consecutive two-hour period constitute violations of state and federal law and need to be tracked more closely as violations of the Clean Air Act requiring enforcement action.

Meteorological Factors Impact Flare Flame Size and Flare Destruction Efficiency

Smoking flares serve as indicators of low performance from flare operations. Recent studies examining the 98-99% efficiency rate assumed since the early 1980's show that this efficiency rate does not take into account additional factors such as wind speed which greatly impacts the efficiency of flame destruction by influencing the size of the flare flame. As the flare's flame decreases, the flare's efficiency levels drop dramatically thus resulting in much higher levels of pollutant discharge.

EPA studies conducted in the early 1980's do not take into account environmental factors that may affect flare efficiency. "There is no suggestion [in the EPA study] that combustion efficiencies may depend on parameters that influence flame size, and consequently heat releases, such as stack velocities and wind speeds."[11] A recent study conducted by research scientists in Canada and published in the Journal of the Air & Waste Management Association (JAWMA), noted that these factors can greatly influence the ability of flares to destroy pollutants sent through vapor streams. Specifically, researchers found that wind speed played a significant role in determining combustion efficiency. According to the study, wind speed velocity greatly impacts the size of the flame "decreases in flame size occur in a significant manner with increasing stoichiometric mixing ration, wind speeds, and stack exit velocities."[12] As flame size decreases flame efficiency also decreases "because more air is entrained into large flames than small flames and consequently more oxygen is available and more heat can be dissipated by large flames, resulting in a greater combustion efficiency.[13]

Increases in wind velocity correlate with decreases in destruction efficiency, The study further identified the rate of efficiency attributed to various wind speeds. Specifically, combustion efficiencies decreased rapidly as wind speed increased from 1 to 6m/sec.[14] "As wind speeds increased beyond 6m/sec, combustion efficiencies tended to level off at values between 10 and 15%."[15]

Areas like Port Arthur typically have wind speeds higher than one meter per second. Wind speeds at this level decrease pollutant waste gas and air mixing for combustion. Data taken from the National Weather Service indicates that average annual wind speed for Port Arthur equaled 4.3 meters per second.[16] The average wind speed for the months of February through April, when winds speeds are typically greater, averaged around 5.2 meters per second.[17] Daily wind speeds in Port Arthur can sometimes even reach levels as high as 11.2 meters per second as indicated in Table A.[18] The JAWMA study notes that "[t]heoretical considerations and observational evidence suggest that flare combustion efficiency typically may be at ~70% at low wind speeds (U 3.5 m/sec). They should be even less at higher wind speeds." [19]

Using this model and considering local wind speed, destruction efficiency rates in Port Arthur can be assumed to be worse than 70%, and not 98-99% as assumed by facility operators. Additionally, flare stacks typically usually stand anywhere from 10 to 100 meters tall.[20] Wind speeds near the flare flame (located at the tip of the flare) are typically much stronger than those averaged for ground wind speeds. If this is true, then even lower destruction efficiency rates can be assumed for the Port Arthur area. Because of these lower efficiency rates, the flaring process will produce higher levels of pollutant discharge than originally suspected.

Flaring May Produce More Harmful By-Products Than Originally Suspected.

The JAWMA study also reveals that flaring does not always produce the harmless results predicted by flare operators. Byproducts of the flaring process are usually assumed to be entirely composed of relatively innocuous by-products such as carbon dioxide (CO_2) and water (H_2O). According to the study, "[c]ombustion is complete if all combustibles (i.e. VOC's) are converted to CO_2 and water, while incomplete combustion results in some of the VOC's being altered or converted to other organic compounds such as aldehydes or acids."[21] The JAWMA study reveals that the flaring process may actually produce more harmful pollutants than water and CO_2.

> …few studies appear to confirm that the conversion is to H_20 and CO_2 rather than to gases with more complex molecular structures such as polycyclic aromatic hydrocarbons and volatile organic compounds, which are indicative of incomplete combustion. There seems to have been little motivation to conduct such studies because they are expensive and because flares have appeared to be a reliable conversion mechanism.[22]

Reports prepared by the Emission Inventory Improvement Program, a jointly sponsored effort of the State and Territorial Air Pollution Program Administrators/ Association of Local Air Pollution Control Officials (STAPPA/ALAPCO) and EPA also indicate that increased air pollution will be created by inefficient flares:

> When a flare is not operating properly, incomplete combustion can occur. The incomplete combustion of many organic compounds can result in the formation of aldehydes and organic acids that may create additional air pollution problems.[23]

Evidence of incomplete combustion must be examined and corrected. Flare systems are only an effective means of waste gas disposal if they are operating efficiently. The Environmental Protection Agency is charged with protection of the public health and environment. Studies of air pollution discharge in the Port Arthur area indicate that the health of residents in Port Arthur is being compromised. Emissions include many hazardous pollutants such as benzene and butadiene. Benzene is a known carcinogen and butadiene is a suspected human carcinogen. Refineries and chemical plants in Port Arthur are releasing high levels of these pollutants into the surrounding area which are directly impacting the health and welfare of the residents of Port Arthur, many of whom live right on the fenceline neighboring these facilities.

Recommendations

Evidence from Port Arthur refineries and chemical plants reveals that flare combustion technology is performing poorly. Factors such as wind speed and flame size may decrease efficiency rates to as low as 10-15% when wind speeds are greater than six meters per second, thus drastically increasing the total pollutant amount discharged from these flares as compared to amounts reported using the 98-99% destruction efficiency rate. To address this problem, EIP recommends that EPA and the Texas Commission on Environmental Quality (TCEQ) take the following actions:

- ***Further Investigations**:* Smoking flares indicate that flare systems at these facilities are not operating as efficiently as reported. EIP urges EPA and TCEQ to conduct further investigations to ensure that flare technology is satisfactorily destroying pollutants emitted through waste streams at these facilities in Port Arthur, Texas and elsewhere and to take an active role in requiring facilities to reduce the level of emissions produced through upsets, startup, shutdown, and maintenance events.
- ***Better Reporting**:* Facilities' reports do not distinguish between opacity events and events where smoke is visible from flares. In addition, reports of smoke are entirely dependent on visual observations made by workers at these facilities who may miss many events. EPA and TCEQ must require accurate reporting of emission discharges from flare operating systems and improved reporting requirements so as to better distinguish between reporting of smoking flare events and opacity events which are not related to flares. Reports of VOC's, H_2S, and other emissions should be based on much more accurate estimates of flare performance that take into account factors which diminish combustion efficiency.
- ***Enforcement of Smoking Violations*:** Sources are required under state and federal law to ensure that flares will not smoke for more than five minutes in a consecutive two hour period. Yet, many sources report repeated violations of flares which smoke beyond five minutes in their upset reports. In fact, Huntsman reported several smoking events which lasted as long as three hours. EPA and TCEQ must enforce violations of the smoking flare requirements and ensure that sources are abiding by state and federal law.
- ***Better Technology*:** Recent studies indicate that flare combustion technology is not performing at expected levels of efficiency when conditions such as high wind speed are present. EPA and TCEQ must require companies to improve current technology and enhance flare design to rectify the affects of meteorological conditions on flare combustion.
- ***Flare Technology Should Not Be Included as Clean Technology:*** EPA is currently considering expediting permitting under the Clean Air Act for new categories of pollution control technology. Given the outdated and likely inaccurate data regarding flare combustion efficiency, flares should not be

considered a “clean technology” which would be exempt from Clean Air Act New Source Review permitting and monitoring requirements.

ENDNOTES

[1] Environmental Integrity Project, Accidents Will Happen (2002).

[2] SO_2 is a by-product created from combustion of H_2S. If H_2S is not completely burned off in the flaring process because of inadequate flaring then SO_2 numbers will actually decrease.

[3] USEPA Office of Air Quality Planning and Standards AP-42 Fifth Edition, Volume I: Stationary Point and Area Sources 13.5-1 (2000). Also available on the web at www.epa.gov/ttn/chief/ap42.

[4] USEPA Office of Air Quality Planning and Standards, Regulatory Impact Analysis for the Petroleum Refinery NESHAP, Revised Draft (1994).

[5] Not all flares operate equally. Flares may be either elevated or ground level. Elevated flares usually can accept larger capacities of waste gas and have a flame located at the tip of a tall stack ranging from 10-100 feet. This high elevation also exposes these flares to atmospheric disturbances such as wind and precipitation. Elevated flares also vary between air-assisted flares and steam-assisted flares which also differ in their performance. Information relating to the type of ground level flare being used at each facility was not available for the purposes of this report. Ground level flare systems are usually more complex and consist of multi-point flares. These flare systems are typically thought to be more efficient than older elevated flare systems. The BASF plant in Port Arthur uses a ground level flare system which has experienced some initial startup problems. Motiva, Atofina, Chevron, and Premcor still utilize elevated flares.

[6] Texas law states that "Opacity shall not exceed 30% averaged over a six-minute period…Opacity shall not exceed 20% averaged over a six-minute period for any source on which construction was begun after January 31, 1972." 30 Tex. Admin. Code §111.111 (2002).

[7] Supra note 3 at 13.5-3 and Texas Natural Resource Conservation Commission, Air Permit Technical Guidance for Chemical Sources: Flares and Vapor Oxidizers (2000). TNRCC lists the destruction efficiency rate for at 98% for generic VOC's and 99% for compounds containing no more than three carbons that contain no elements other than carbon and hydrogen in addition to the following compounds: methanol, ethanol, propanol, ethylene oxide and propylene oxide.

[8] USEPA, Flare Efficiency Study, EPA-600/2-83-052 (1983). These studies were limited primarily to natural gas processing plants and burned a much simpler type of organic chemical than most refineries and chemical plants burn today.

[9] Supra note 4.

[10] 40 CFR §60.18 (2000). Texas regulations have a similar provision: "Visible emissions from a process gas flare shall not be permitted for more than five minutes in any two-hour period…" 30 Tex. Admin. Code §111.111 (4)(A) (2002)

[11] Douglas M. Leahey, Katherine Preston and Mel Strosher, Theoretical and Observational Assessment of Flare Efficiency, 51 J. Air & Waste Mgmt. 1610, 1616 (2001).

[12] Id. at 1616.

[13] Id. at 1611.

[14] Id.

[15] Id.

[16] National Weather Service, *available at* http://www.nws.noaa.gov.

[17] Id.

[18] Id.

[19] Supra note 11 at 1615.

[20] Supra note 2 at 13.5-1.

[21] Supra note 11.

[22] Id.

[23] Emission Inventory Improvement Program, How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates. Volume II, Chapter 12 (2000).